DISEASE DETECTION SURVEY
Air Pollution

Tonto National Forest
Arizona

Sierra Ancha Experimental Forest
Arizona

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In October 1971, Robert Loomis, plant pathologist in the Forest Service Insect and Disease Branch; assisted by H. L. Lance, Assistant Ranger, Globe Ranger District; and Gary Wittman, Assistant Ranger, Tonto Basin Ranger District; examined selected areas on or near the Tonto National Forest, Arizona. The purpose of the survey was to determine if acute injury had occurred to forest vegetation from SO_2 emitted by the Inspiration copper smelter located in Miami, Arizona. Symptoms of acute SO_2 injury were found on forest vegetation in two locations within 3.5 miles of the smelter.

Method.--A detection system, consisting of 9 sulfation plate stations and 10 vegetative observation areas, was established in June 1971. These sulfation plate stations and observation areas are located on the Globe, Roosevelt, and Tonto Basin Ranger Districts, and the Sierra Ancha Experimental Forest (Figures 1 and 2). Where possible, the sulfation plate stations and observation areas were established together in species type and location most susceptible to SO_2 injury. By locating the sulfation plates and observation areas together, we may be able to determine if there is a relationship between sulfation rate and the presence or absence of plant injury. By finding areas most susceptible to SO_2 injury, the detection system is made more sensitive to possible SO_2 injury.

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EXPERIMENT STATION

Figure 1.

GLOBE RANGER DISTRICT
TONTO NATIONAL FOREST
ARIZONA
1970
Scale
1 ½ 0 1 2 3 4 5 Miles

LEGEND
Ranger District Boundary
National Forest Land

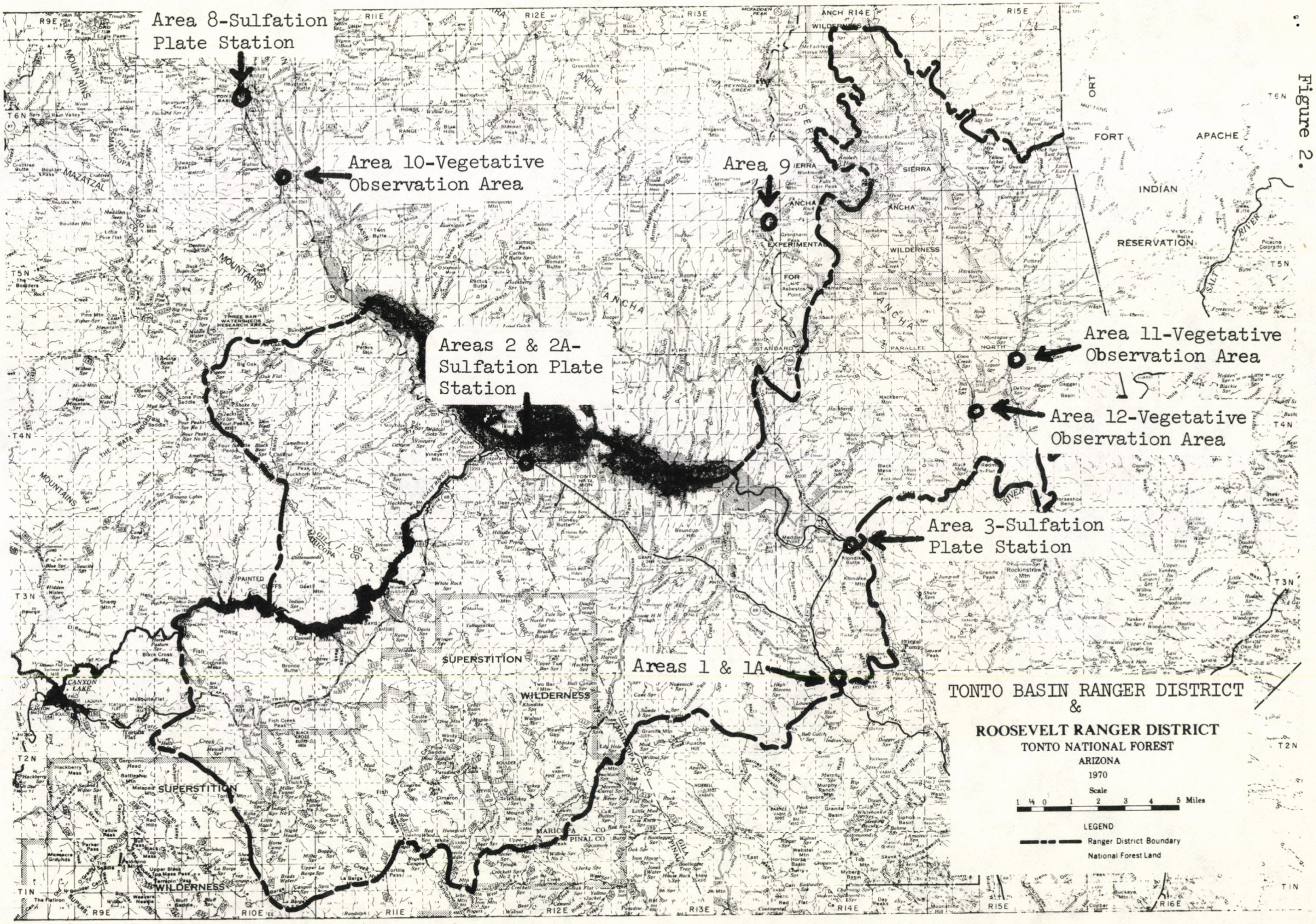

Area 8-Sulfation Plate Station
Area 10-Vegetative Observation Area
Area 9
Areas 2 & 2A-Sulfation Plate Station
Area 11-Vegetative Observation Area
Area 12-Vegetative Observation Area
Area 3-Sulfation Plate Station
Areas 1 & 1A
TONTO BASIN RANGER DISTRICT
&
ROOSEVELT RANGER DISTRICT
TONTO NATIONAL FOREST
ARIZONA
1970
Scale
1 ½ 0 1 2 3 4 5 Miles
LEGEND
Ranger District Boundary
National Forest Land

Figure 2.

Considerations for establishing observation areas include:

1. Presence of a variety of trees and associated plants growing in the area. One phase in evaluating possible SO_2 injury to plants is to determine if similar injury has occurred to a variety of plant species.1/

2. The observation areas should have adequate soil moisture. Plants growing in areas with adequate soil moisture and high humidity are more susceptible to SO_2 injury than plants growing under arid conditions.1/

The foliage of trees and associated plants was examined for the interveinal bleaching, interveinal necrosis, and tip burn typical of acute SO_2 injury. In addition, leaf and needle abnormalities from other causes were noted for future reference.

Results.--The following plant species were examined for evidence of acute SO_2 injury:

Forest Trees

Ponderosa pine (Pinus ponderosa)
Pinyon pine (Pinus edulis)
Alligator bark juniper (Juniperus deppeana)
Arizona sycamore (Platanus wrightii)
Gambel oak (Quercus gambelii)
Shrub live oak (Quercus turbinella)
Emory oak (Quercus emoryi)
Arizona white oak (Quercus arizonica)
New Mexico locust (Robinia neomexicana)
Arizona walnut (Juglans major)
Ash (Fraxinus spp.)
Maple (Acer spp.)
Willow (Salix spp.)
Mesquite (Prosopis spp.)
Wild cherry (Prunus spp.)
Box elder (Acer negundo var. interius)
Cottonwood (Populus fremontii)
Desert hackberry (Celtis pallida)

Forest Plants and Shrubs

Poison ivy (Toxicodendron radicans)
Grape (Vitis spp.)
Manzanita (Arctostaphylos spp.)
Skunkbush (Rhus trilobata)
Brickellbush (Brickellia spp.)

1/ Air Pollution Control Assoc. 1970. Recognition of Air Pollution Injury to Vegetation: A Pictorial Atlas. Jacobson, J. S., and A. C. Hill, Ed. Pittsburgh, Pa.

Forest Plants and Shrubs

Desert tobacco (Nicotiana trigonophylla)
Tree tobacco (Nicotiana glauca)
Thoroughwort (Eupatorium herbaceum)
Mexican elder (Sambucus mexicana)

Tree and plant condition was noted as follows:

1. Symptoms of acute SO_2 injury were noted in Area 6 on brickellbush and thoroughwort (Figure 3). Leaf markings were also noted on sycamore; however, further examination is necessary in order to determine if SO2 air pollution is contributing to this foliage abnormality.

A chlorotic mottle or fleck of unknown cause was noted on the older ponderosa pine needles. This needle marking had begun to show on some of the current year's needles. Other trees and plants examined in the area appeared to have normal foliage.

2. Symptoms of chronic and acute SO_2 injury were noted on a variety of tree and plant species in Area 13 (W. Bohme ranch and vicinity). Examples of this injury are shown in Fugures 4, 5, and 6 on tree tobacco, skunkbush, ash, Arizona walnut, and mesquite. Other tree and plant species which exhibited symptoms of acute SO_2 injury include: cottonwood, Mexican elder, hackberry, and desert tobacco. The needles of several pinyon pine trees had some tip burn; however, this symptom was not found consistently in the area.

3. The foliage of several Arizona walnut trees in Area 11 had leaf markings similar to symptoms of SO_2 injury. Other foliage diseases probably caused these markings because (1) other trees and plants growing in the area did not exhibit symptoms of SO_2 injury, and (2) Area 11 is more than 22 miles from the smelter at Miami.

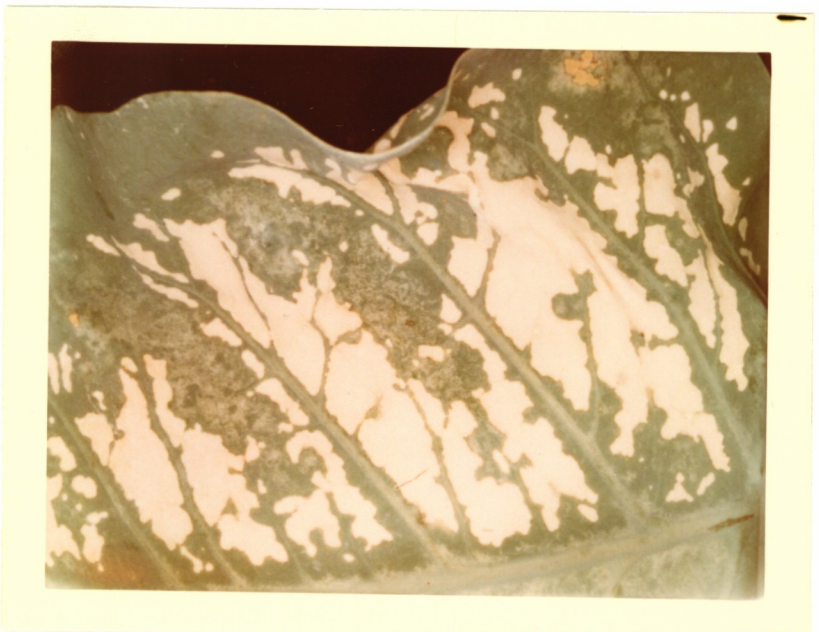
4. The foliage of forest trees and associated plants in all other observation areas appeared normal.

Figure 3.

Symptoms of acute SO_2 injury on brickellbush, Area 6 (Warnica Springs Picnic Area), Globe Ranger District.

Symptoms of acute SO_2 injury on thoroughwort, Area 6 (Warnica Springs Picnic Area), Globe Ranger District.

Figure 4.



Symptoms of acute SO_2 injury on tree tobacco, Area 13 (W. Bohme Ranch).

Symptoms of acute SO_2 injury on ash, Area 13 (W. Bohme Ranch).

Figure 5.

Symptoms of acute SO_2 injury on Arizona walnut, Area 13 (W. Bohme Ranch).

Symptoms of chronic SO_2 injury on mesquite, Area 13 (W. Bohme Ranch).

Figure 6.

Symptoms of acute SO_2 injury on skunkbush, Area 13 (W. Bohme Ranch).

Sulfation plate data for the period July 1971-November 1971 are as follows:

Area 1 - Roosevelt Ranger District

Month	Days exposed	* Sulfation rate (Micrograms $SO_3/cm^2/day$)
Jul.	31	** <Detectable minimum
Aug.	33	1.4
Sep.	32	1.3
Oct.	30	7.3
Nov.	46	10.3

Area 1A - Roosevelt Ranger District

Jul.	31	2.8
Aug.	33	<Detectable minimum
Sep.	32	1.3
Oct.	30	6.0
Nov.	46	8.3

Area 2 - Roosevelt Ranger District

Jul.	31	2.8
Aug.	33	<Detectable minimum
Sep.	32	<Detectable minimum
Oct.	30	1.3
Nov.	33	<Detectable minimum

Area 2A - Roosevelt Ranger District

Jul.	31	1.5
Aug.	33	<Detectable minimum
Sep.	32	<Detectable minimum
Oct.	30	1.3
Nov.	33	<Detectable minimum

* Corning Laboratories, Inc., Cedar Falls, Iowa, supplies and analyzes all sulfation plates.

** Detectable minimum for 30-day period (micrograms $SO_3/cm^2/day$)
Jul. 1971-Sep. 1971 - 1.0
Oct. 1971 - 0.8

NOTE: The Inspiration copper smelter was closed down during the period July 1-August 31, 1971, due to a labor dispute.

Area 3 - Roosevelt Ranger District

Month	Days exposed	* Sulfation rate (Micrograms $SO_3/cm^2/day$)
Jul.	31	3.5
Aug.	33	** <Detectable minimum
Sep.	32	<Detectable minimum
Oct.	36	<Detectable minimum
Nov.	40	<Detectable minimum

Area 4 - Globe Ranger District

Jul.	32	<Detectable minimum
Aug.	30	2.9
Sep.	34	2.4
Oct.	27	1.5
Nov.	30	<Detectable minimum

Area 4A - Globe Ranger District

Jul.	32	2.7
Aug.	30	1.5
Sep.	34	<Detectable minimum
Oct.	27	1.5
Nov.	30	<Detectable minimum

Area 5 - Globe Ranger District

Jul.	32	<Detectable minimum
Aug.	30	2.9
Sep.	34	<Detectable minimum
Oct.	27	<Detectable minimum
Nov.	30	<Detectable minimum

*Corning Laboratories, Inc., Cedar Falls, Iowa, supplies and analyzes all sulfation plates.

**Detectable minimum for 30-day period (micrograms $SO_3/cm^2/day$)
Jul. 1971-Sep. 1971 - 1.0
Oct. 1971 - 0.8

NOTE: The Inspiration copper smelter was closed down during the period July 1-August 31, 1971, due to a labor dispute.

Area 6 - Globe Ranger District

Month	Days exposed	* Sulfation rate (Micrograms $SO_3/cm^2/day$)
Jul.	32	** <Detectable minimum
Aug.	30	4.4
Sep.	34	6.8
Oct.	27	4.1
Nov.	30	4.8

Area 7 - Globe Ranger District

Jul.	32	<Detectable minimum
Aug.	30	4.4
Sep.	34	1.2
Oct.	27	<Detectable minimum
Nov.	30	<Detectable minimum

Area 8 - Tonto Basin Ranger District

Jul.	31	<Detectable minimum
Aug.	29	4.6
Sep.	30	<Detectable minimum
Oct.	27	<Detectable minimum
Nov.	33	<Detectable minimum

Area 9 - Sierra Ancha Experimental Forest

Sep.	34	<Detectable minimum
Oct.	28	<Detectable minimum
Nov.	29	<Detectable minimum

* Corning Laboratories, Inc., Cedar Falls, Iowa, supplies and analyzes all sulfation plates.

** Detectable minimum for 30-day period (micrograms $SO_2/cm^2/day$)
Jul. 1971-Sep. 1971 - 1.0
Oct. 1971 - 0.8

NOTE: The Inspiration copper smelter was closed down during the period July 1-August 31, 1971, due to a labor dispute.

Discussion.--Diagnosis of air pollution injury to vegetation is complicated by environmental, insect, and other disease factors. These factors can cause leaf and plant symptoms which appear similar to air pollution injury. In addition, the occurrence or severity of air pollution-caused plant injury is determined not only by the pollutant concentrations and duration of exposure, but by many environmental factors which can affect individual plant sensitivity. These factors include light, moisture, temperature, and nutrient relations.2/

To date, the only places we have found symptoms of acute SO_2 injury to Southwestern forest vegetation have been within 4 miles of copper smelters located at Miami and Morenci, Arizona.3/ We do not presently have enough data to know, for Southwestern conditions, if acute or chronic injury is occurring to forest vegetation at distances greater than 4 miles from sources of SO_2. Additional surveys, such as the one reported here, will help to establish where injury is occurring, and what the impact of SO_2 might be on Southwestern forest vegetation.

The needle mottle or fleck on ponderosa pine, noted in Area 6, has been found in New Mexico and Arizona for many years. This needle marking can be found in areas far from any known sources of air pollution, as well as in areas close to industrial activity. We are now attempting to determine if the appearance of this marking is related to a particular time of year. In addition, we are working with Forest Service Research plant pathologists, and members of the University of Arizona Department of Plant Pathology, in trying to determine the cause of this needle marking.

Sulfation plates are being used to determine if SO_2 and other sulfur compounds are reaching the vegetative observation areas.4/ The sulfation plates are exposed for approximately 30 days, during which time sulfur compounds react with the lead dioxide in the plate. The product of these reactants is then measured and expressed as micrograms $SO_3/cm^2/day$.5/ This is commonly called the sulfation rate. To date, no relationship has been noted between average monthly

2/ Treshow, M. 1970. Environment and Plant Response. McGraw-Hill Book Co., N.Y. 422 p.
3/ Loomis, R. 1971. Disease Detection Survey, Air Pollution. Apache National Forest, Arizona.
4/ Tucson Advisory Committee on Air Pollution. 1971. Air Pollution in Tucson: A Report to the Mayor and Council of the City of Tucson. Edited by R. Caldwell. 141 p.
5/ Huey, N. A. 1968. The Lead Dioxide Estimation of Sulfur Dioxide Pollution. J. Air Poll. Control Assoc. 18: 9.

sulfation rates and plant injury. Comparisons have not been possible because most of the acute plant injury we have found has not been in the vicinity of our sulfation plate stations. Therefore, Area 13 appears to be an excellent location in which to establish a sulfation plate station because of its history of air pollution-caused plant injury.

In order to get some idea of sulfation plate reliability, duplicate plates were exposed in Area 1, Area 2, Area 4, and in three other locations in Arizona and New Mexico. The sulfation rates of several individual plate-pairs varied considerably; however, when all plate-pairs are considered, there is a highly significant correlation between the sulfation rates on each of the plate-pairs ($R = 0.859$ with 26 degrees of freedom). There is no significant difference between the average of the means of each set of plate-pairs ($T = 1.030$ with 26 degrees of freedom).

A map is attached which shows the areas included in the 1971 air pollution detection survey.

Recommendations.--

1. Examine selected areas of the Tonto National Forest, in the late summer of 1972, for evidence of acute or chronic injury caused by SO_2.

2. Establish a sulfation plate station at Area 13 (W. Bohme Ranch).

3. Continue the present sulfation plate network at least until November 1972. More information is needed concerning sulfation rate and the presence or absence of plant injury.

AIR POLLUTION DETECTION SURVEY - 1971
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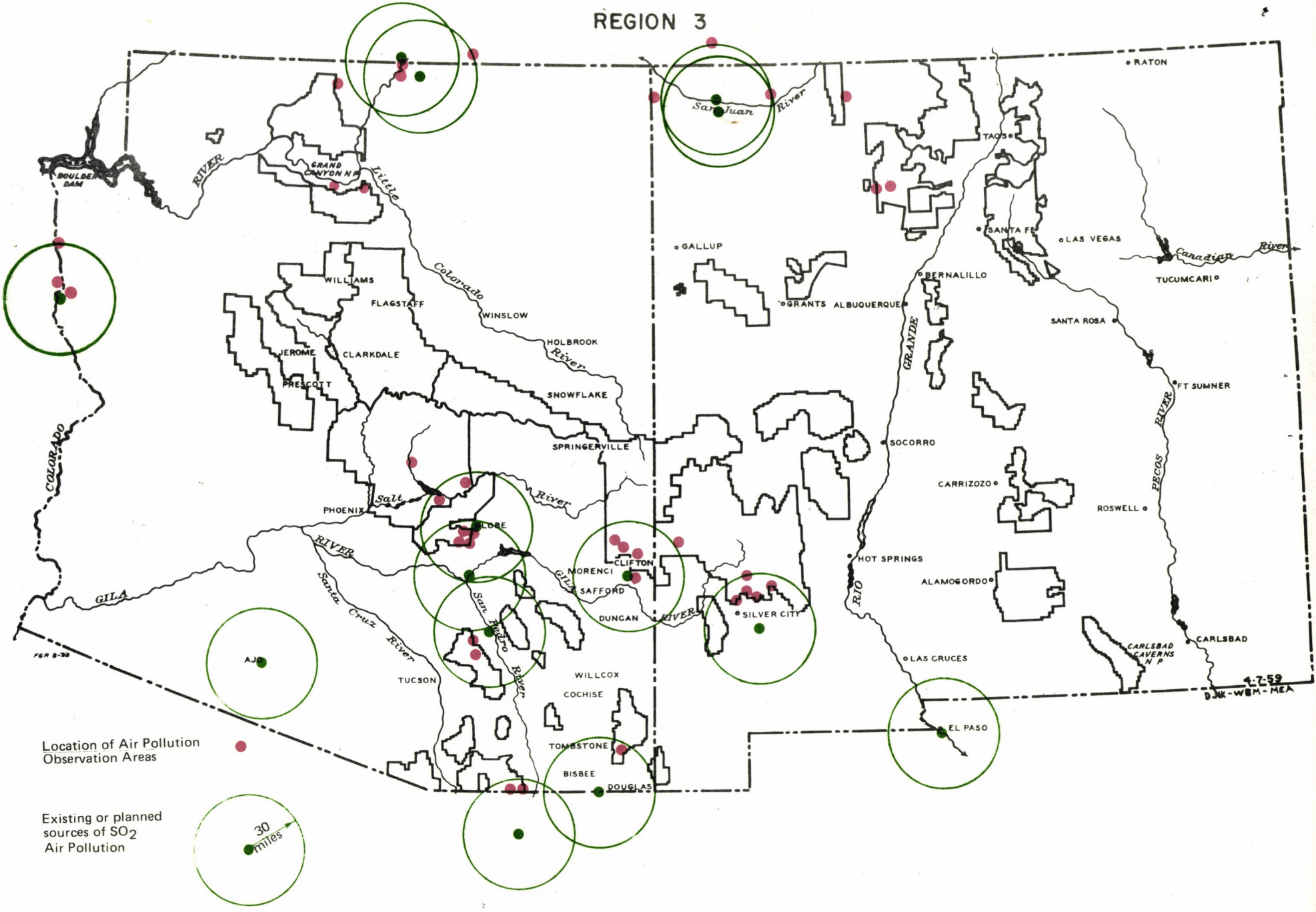

Location of Air Pollution Observation Areas

Existing or planned sources of SO_2 Air Pollution

30 miles